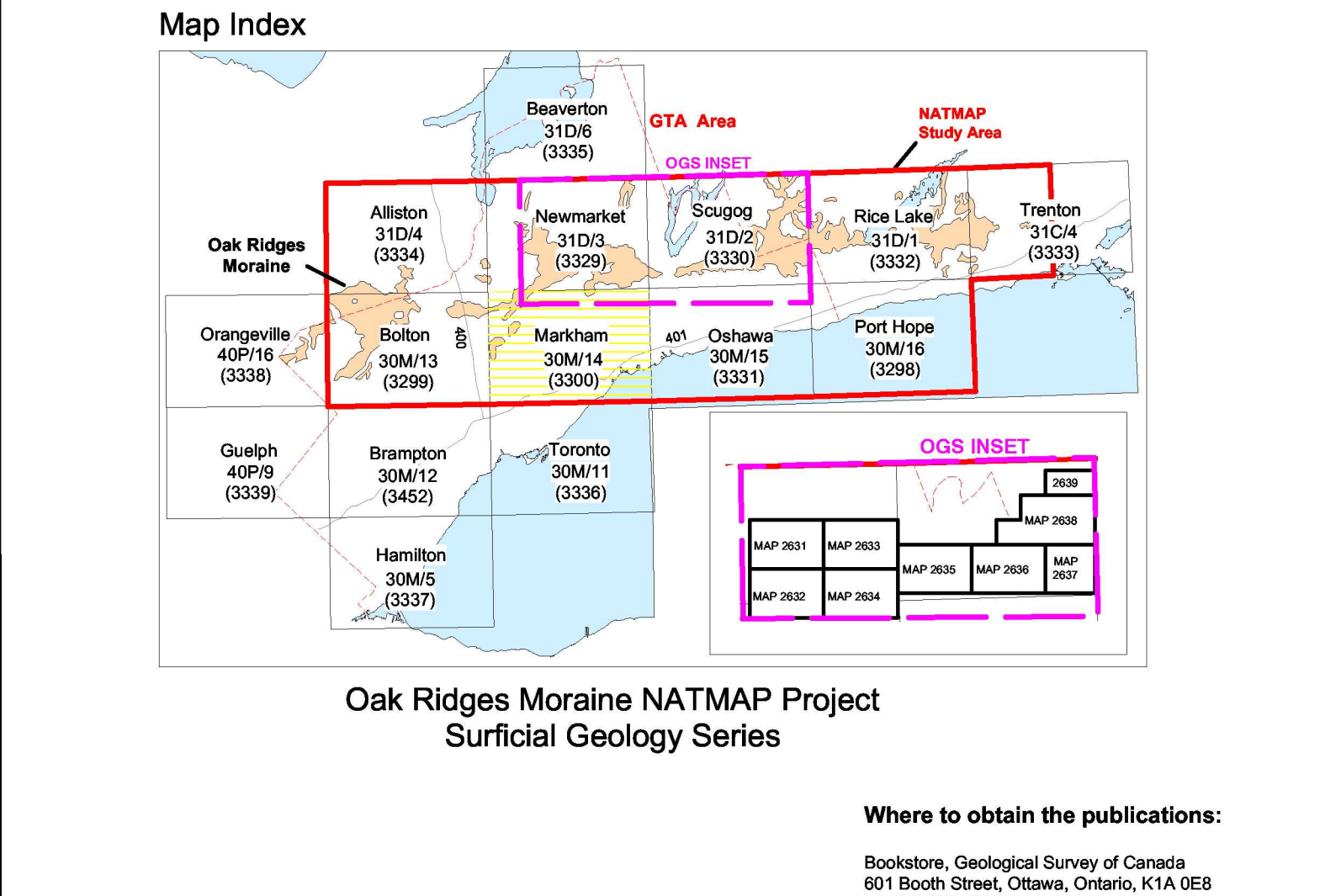


Surficial Geology of the Markham Area, NTS 30M/14, southern Ontario

Scale 1:50 000



Recommended citation:
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INTRODUCTION

NATMAP Oak Ridges Moraine Map series

Markham is one in a series of 15 digital 1:50,000 scale maps summarizing the glacial and postglacial deposits of the Oak Ridges Moraine and Greater Toronto Area (GTA) (index map). The series is sponsored by the National Mapping Program (NATMAP) of the Geological Survey of Canada in collaboration with the Ontario Geological Survey (OGS). These maps complement a series of 1:200,000 scale maps covering the central area of the ORM, published by OGS. The OGS is also publishing two 1:50,000 scale maps (Scugog and Newmarket) using map detail and the expanded legend of the 1:200,000 series. A 1:200,000 scale compilation map of the 1:50,000 maps completes the series (Sharpe et al., 1997).

Objectives and Content

The objective of the map series is to synthesize the geology of the ORM study area as a basis for environmental analysis, particularly hydrogeology. Each map consists of 4 coloured panels: 1) title block, series introduction and regional setting, 2) thematic maps, 3) legend, symbols and geology map, and 4) reference material: map notes, stratigraphic table and series bibliography. The layout is designed to allow folds between the first three panels and to allow the main map and legend to be cut off for field use.

Thematic maps and other features

A thematic map series complements the surficial geology map by providing at a common scale: 1) field site locations and Voronoi polygons of sediment descriptions (Fig. 3); 2) geologic map (Fig. 4) for comparison with other thematic maps; 3) digital elevation model (DEM) (Fig. 5) to allow visualization of relief / terrain elements that shows the pattern and control on drift distribution; 4) bedrock topography map with bedrock geology overlay (Fig. 6); 5) sediment thickness map that shows variation in sediment thickness (Fig. 7). Each map is supplemented with map notes, an explanation of the key geologic terms related to the map unit sequence (stratigraphy) and age relationships, and a series bibliography. The digital map files will be released as part of a CD-ROM data release.

Data sources and structure

The nine maps within the NATMAP area all include new field work complemented by archival field data; combined, most maps have > 1,000 data points. The six maps outside NATMAP and within the GTA (location map) have been re-mapped with a minimum of new field work but include re-assessed archival data. All maps are structured in a Geographic Information System (GIS) with supporting data in a relational database (Russell et al., 1998). This format permits map feature enhancement and analysis (e.g. thematic map series, Figs. 3-7). Surficial geology forms the first layer of a set of regional themes in the area, where Quaternary sediment thickness reaches approximately 200 m. The relational database allows for the digital map files to be easily updated with new data as added.

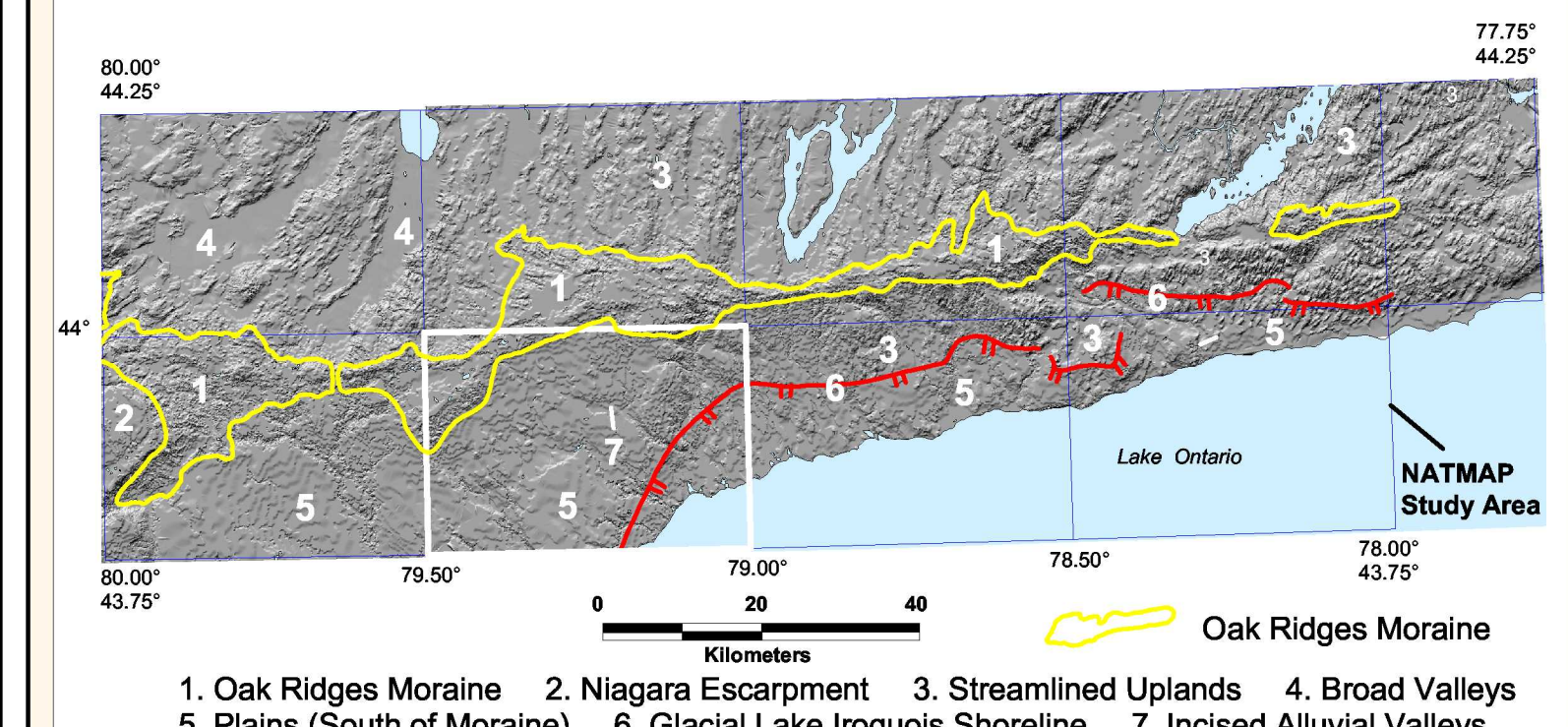


Figure 1. Regional Physiography:

Seven regional landscape elements are shown on a digital elevation model (DEM; Kenny et al., 1996; Skinner and Moore, 1997; Kenny et al., 1997). Subdued drumlin uplands, lake-till plains and the Oak Ridges Moraine are prominent in the Markham area.

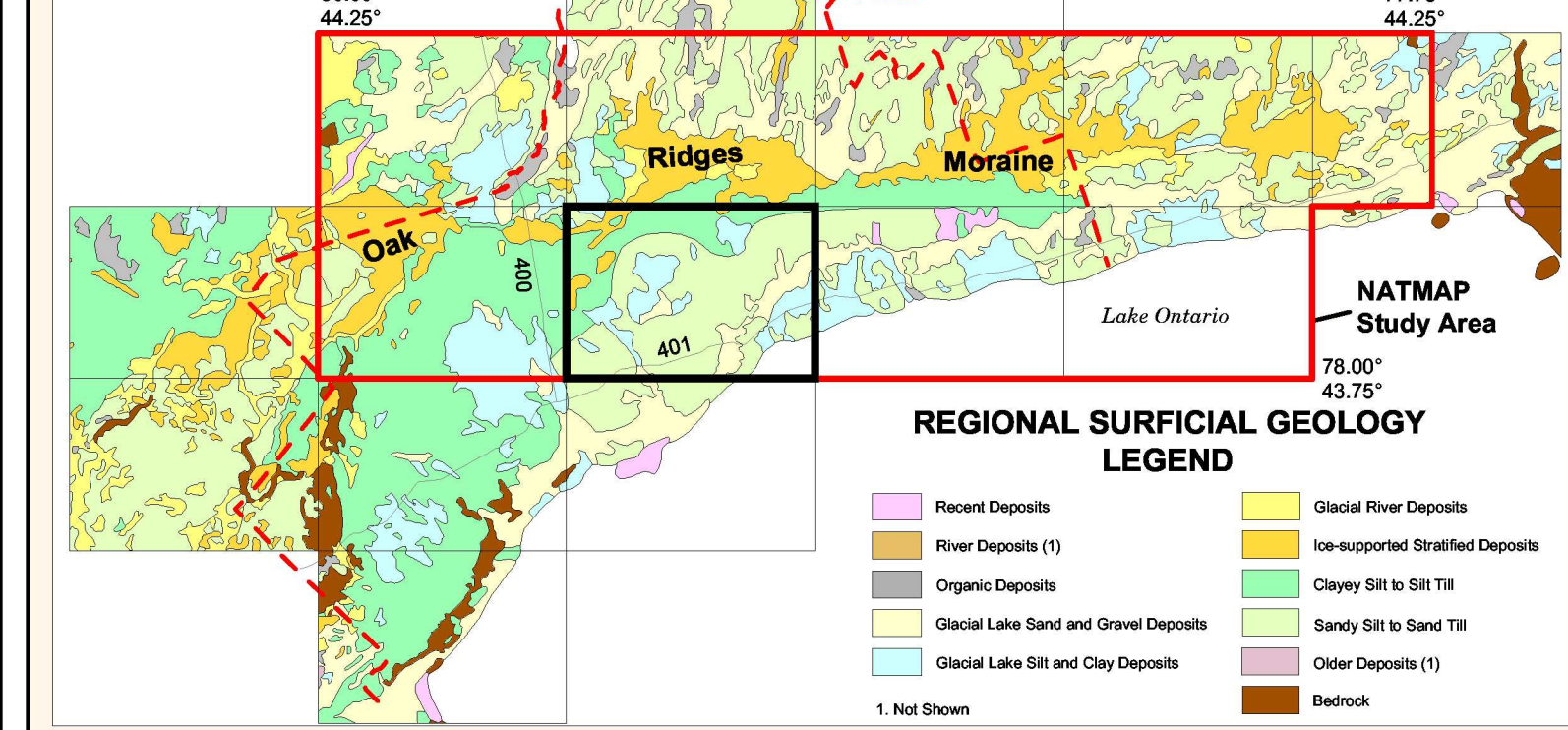


Figure 2. Regional Surficial Geology: Regional surficial geology showing the Markham area in regional context (modified from Barnett et al., 1991). Large areas of Newmarket Till and lake sand are exposed south of the Oak Ridges Moraine. The map legend is the same as that for the main map.

THEMATIC MAPS

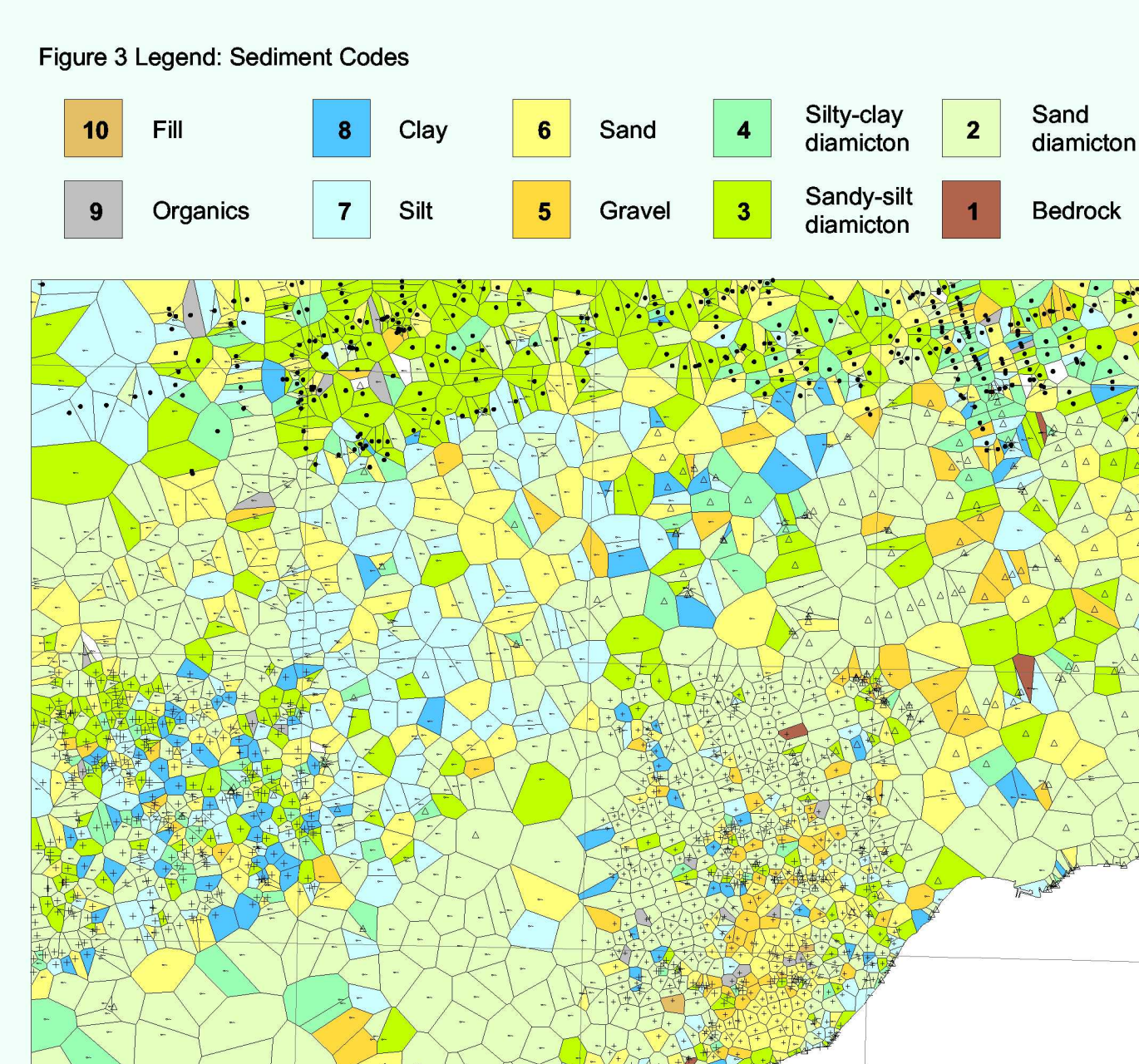


Figure 3. Field sites and material description:

Field sites located at the centre of polygons (Voronoi plot) describe the sediment found and used as ground control for air photo interpretation. Field sites include new GSC (Sharpe, "triangle") and OGS data (Barnett - "dots") and archival OGS data (Karrow "*" and Westgate "-").

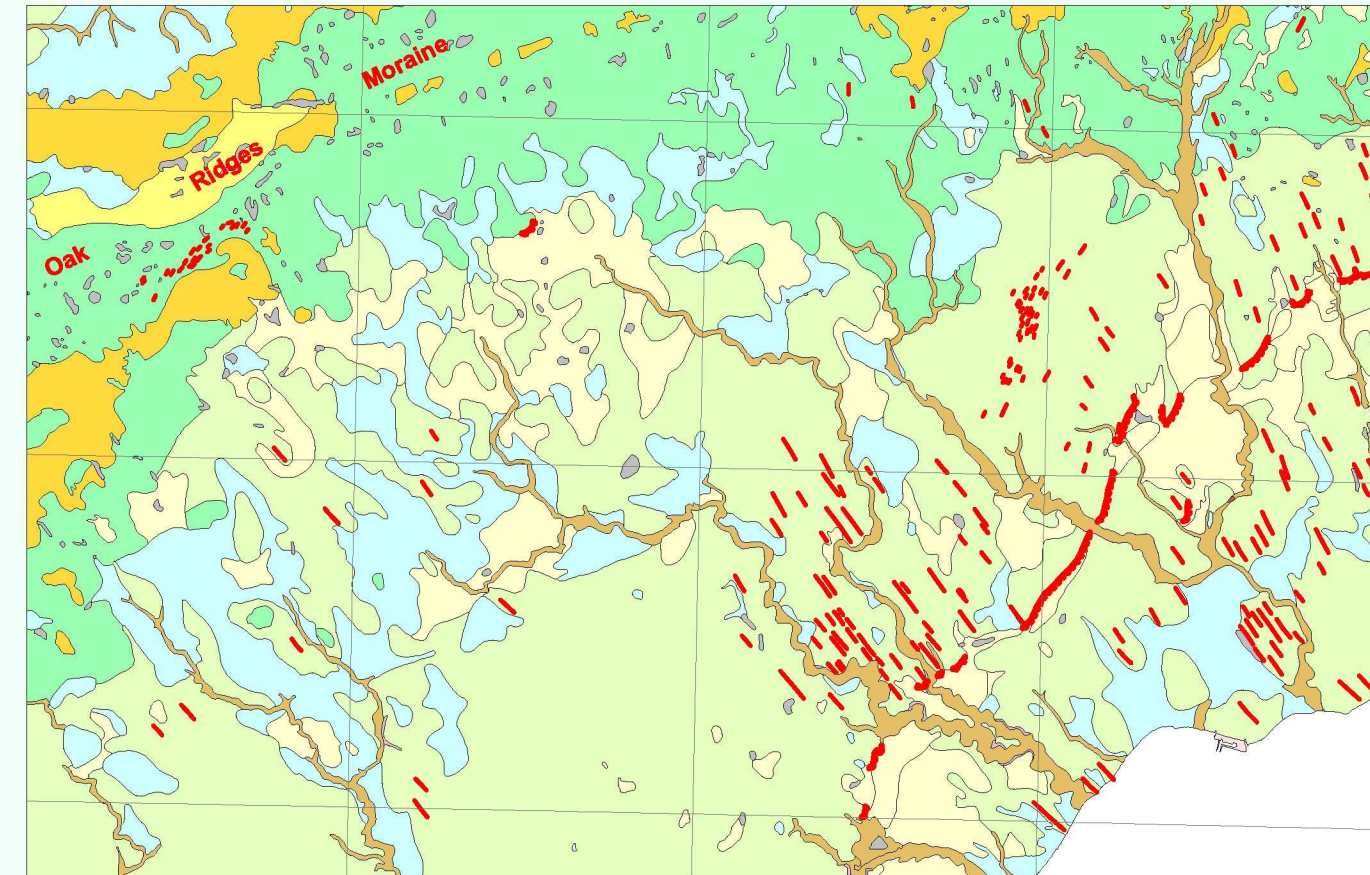


Figure 4. Markham Surficial Geology Map:

Surficial geology map of the Markham area shown at the same scale as other thematic maps permits ease of comparison with sediment descriptions (Fig. 3) or Digital Elevation Model (DEM) (Fig. 5). Long red line is Iroquois shoreline. Short red ticks are drumlins. Legend is same as main map.

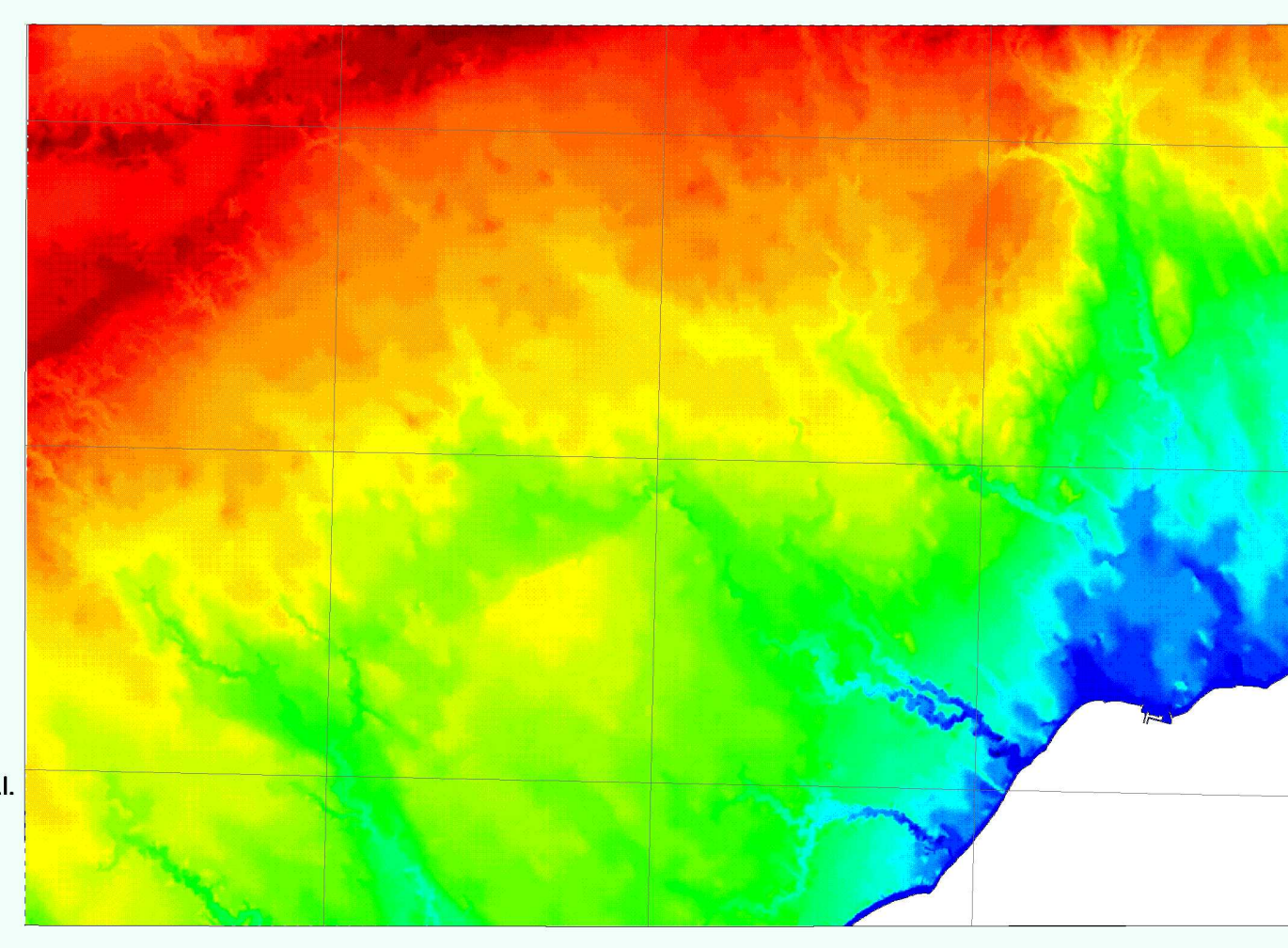


Figure 5. Digital Elevation Model (DEM): DEM (hatched, colour gradient) showing main elements of the landscape, including the Oak Ridges Moraine (Mapa fan), till uplands and deep fluvial gullying.

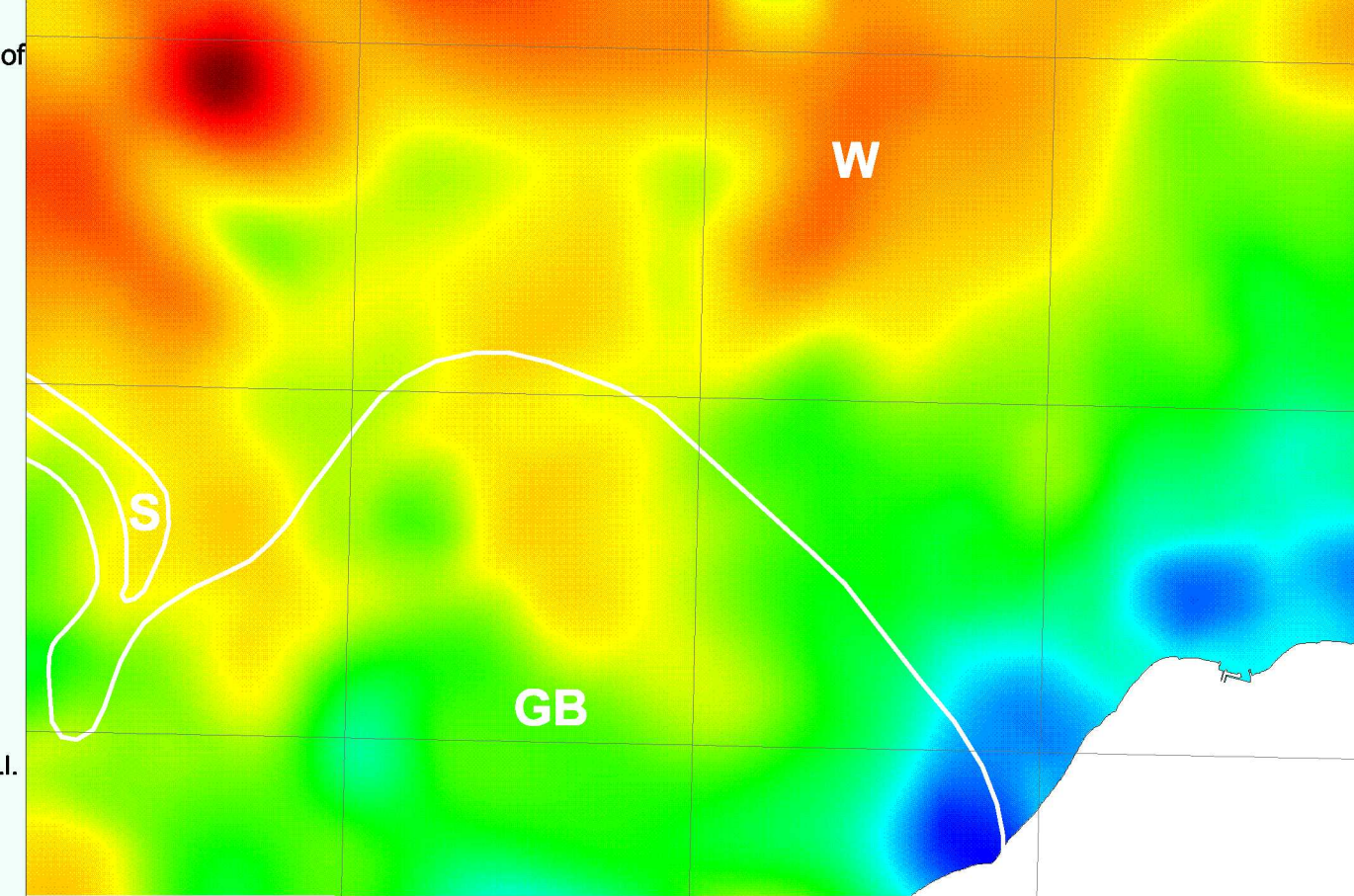


Figure 6. Bedrock topography: Topographic map of the bedrock surface (from Bennett et al., 1997) as all Quaternary-aged sediments were removed. Bedrock valleys are common. Few coincide with valleys on the DEM (Fig. 5). Simcoe Group (S) limestone, Whitby Formation (W) shale and Georgian Bay (GB) formation limestone-shale are shown from Sanford and Baer, 1978).

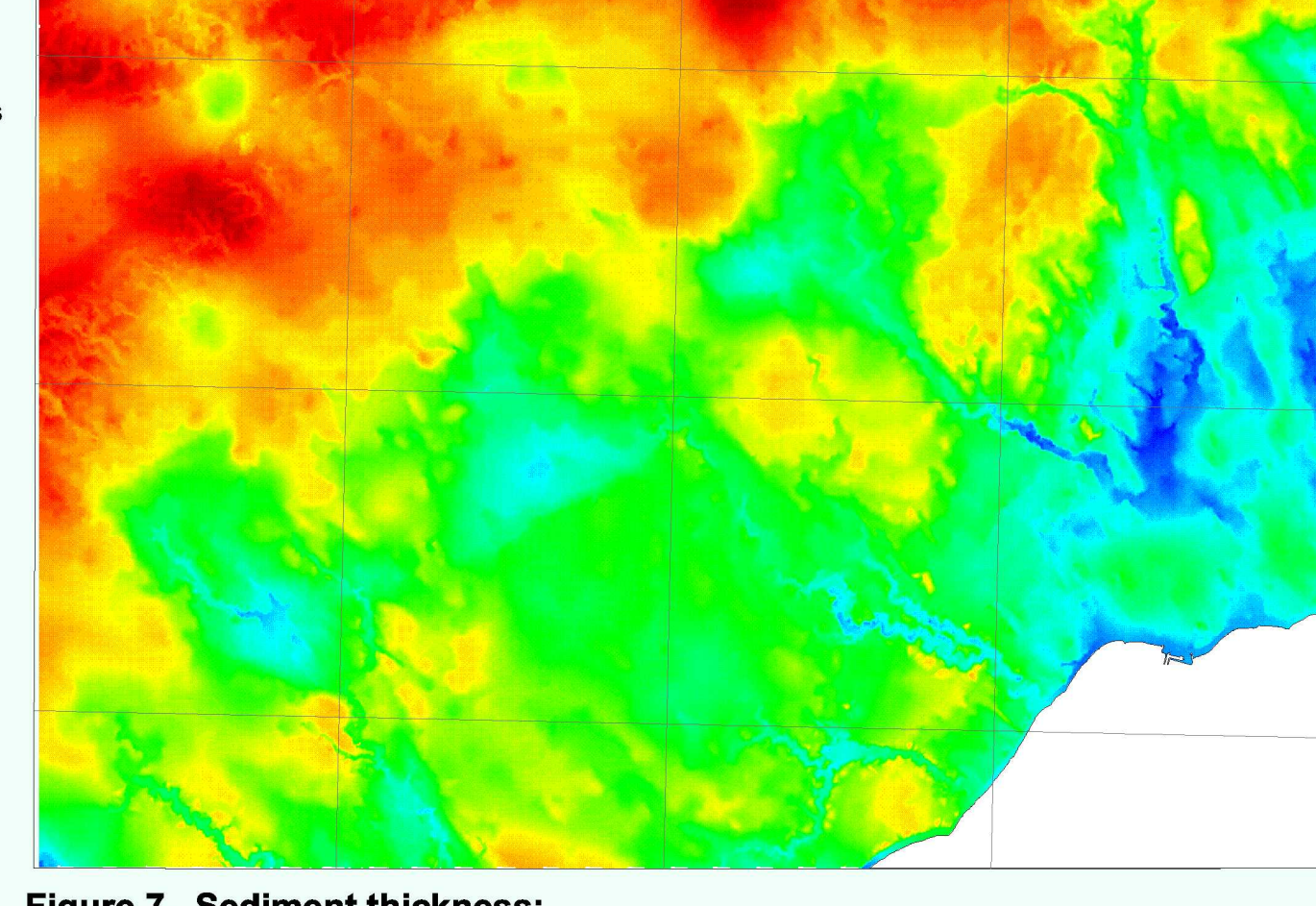


Figure 7. Sediment thickness: Map shows the thickness of Quaternary sediment cover over the bedrock surface (from Russell et al., 1997). In general these sediments are thickest along the ORM and in bedrock channels.

LEGEND

SURFICIAL GEOLOGY OF THE GREATER TORONTO / NATMAP AREA

QUATERNARY PERIOD - last 2 million years

11	Recent Deposits: sand, gravel and diamicton: 1 - 3 m thick; includes wind-eroded, landslide, slope, groundwater seepage, lakeshore deposits and fill
10	River Deposits: sand and gravel a. gravel, sand, silt, clay, mac; 1-2 m thick; occurs on modern floodplains b. gravel, sand, silt, clay; 1-8 m thick; forms river deltas and terraces of early post-glacial age
9	Organic Deposits: peat, muck and marl: 1-7 m thick; occurs in wetlands
8	Glacial Lake Deposits: sand and gravel (minor diamicton) a. sand and silty sand; 1 to >50 m thick; occurs in basin lows and nearshore flats b. gravely sand and gravel; 1-5 m thick; raised shorelines or bars
7	Glacial Lake Deposits: silt and clay, massive to laminated a. silt and clay interbedded with diamicton and some loess tones; 1-10 m thick; occurs in basins b. silt and clay; 1-2 m thick; laminations defined in basin fills
6	Glacial River Deposits: sand and gravel (minor diamicton) a. sand; 1-15 m thick; occurs as eskers, valley fills and terraces b. gravel; 1-15 m thick; occurs as eskers, valley fills and terraces
5	Moraine Deposits: fine sand to gravel a. fine sand, some gravel, minor silt, clay and diamicton; 1-50 m thick; rhythmic beds common b. medium to coarse sand and gravel and diamicton; 1-20 m thick; channels common (a and b occur in disorganized hills, depressions and eskers)
4	Glacial Deposits (fill): clayey silt to sand, 1-2% stone content; occurs in till or lake plains often with interbedded fine sand, silt and clay a. Wildfield / Kettleby b. Hainan c. Tavelsok
3	Glacial Deposits (fill): sandy silt to sand, > 3% stone content; stratified interbeds; 1-50 m thick; forms uplands a. Westwood b. Fort Stanley c. Newmarket/ northern Whitby/ Navanville
2	Lower (drift) Terraces: silt, fine-medium sand, and laminated silt and clay, 1-50 m thick; exposed in bluffs a. Upper Thorncliffe Formation / Clarke beds; b. Seminary / Meadowciffe / Broadfield Hill c. Lower Thorncliffe Formation / Clarke beds; d. Swanborough / Port Hope till; e. Scarborough Formation; f. Dan Formation; m. York Till; n. Stratified/undifferentiated, dominantly sand; o. Stratified sediment, dominantly silt and clay
Unconformity (interval with no deposits and/or major erosion)	

PALEOZOIC (rocks >400 million years in this area)

1	Bedrock: limy mudrock and elastic sedimentary rock a. bedrock-competent b. clastic (sandstone or shale) c. carbonate
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1. Peel/Schomberg ponds above, Lake Ontario/Algonquin below raised shorelines
2. Subglacial and/or proglacial overwash
3. Wildfield south of ORM and Kettleby north of ORM; sub units in units 2-4 are listed in stratigraphic order: a-o
4. Northern till is used to indicate a source area to the north; it may have several age assignments (cf. White, 1975)
5. Moraine till present as surficial stratigraphy on 1:50,000 maps
6. Age unknown

Note: The legend is not strictly stratigraphic; attached stratigraphic table explains age relationships and regional terminology. Not all map units appear on each map.

SYMBOLS

Geological boundary (approximate)	Small ridges	Base of lake-out escarpment (abandoned shore bluff)
Drumlin or fluting	Areas of hummocky topography	Raised shoreline (projected)
Trend, direction of flow known	Areas of sand beach (colliers)	Crest of abandoned beach (at 1901)
Trail of moraine crest	Base of terrace escarpment (fluvial, glaciofluvial)	Border of landslide or zone of groundwater seepage
Kettle	Meltwater flow direction	Sand and gravel pit
Ice-contact slope	Channels	Borehole (GSC/OGS)
		Fill

Note: All symbols may not appear on this map.

NTS LEGEND

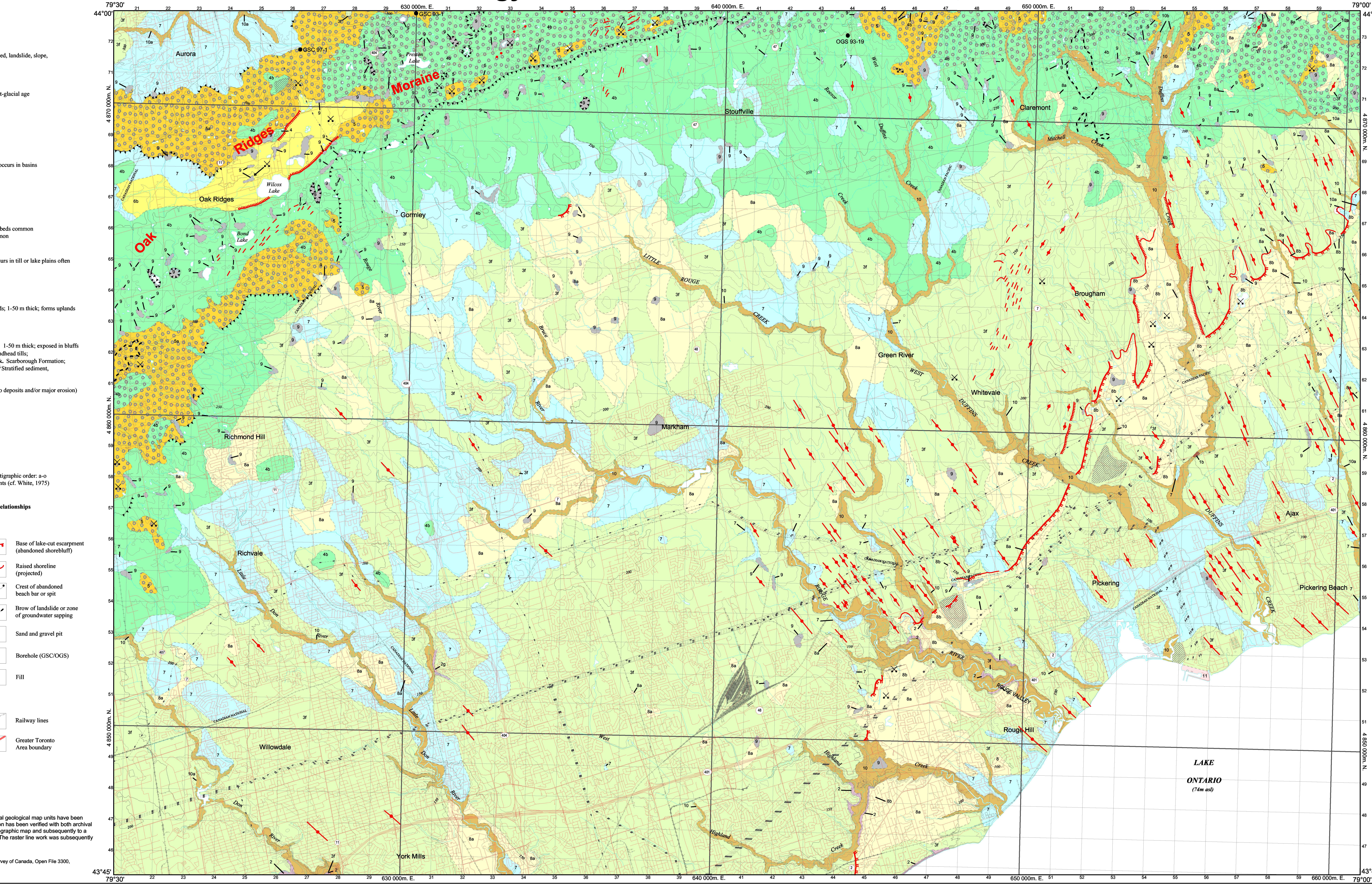
North American Datum 1983	Contour lines (interval lines)	Railway lines
Universal Transverse Mercator Grid - Zone 17	Roads (any type)	Greater Toronto Area boundary

Note: Selected listing.

MAP PRODUCTION

This map has been produced from interpretation of 1:30,000 scale black and white aerial photographs. Individual geological map units have been identified on the basis of landform, surface texture, tonal contrasts and elevation relationships. This interpretation has been verified with both aerial and ground control data (Figure 3). Line work was based on a 1:50,000 NTS topographic map and subsequently a registered choropleth base. The choropleth base was scanned and registered to a NAD 83 datum in MapInfo. The raster line work was subsequently digitized and an attributed vector file built.

Sharpe, D.S. and Bennett, P.J., 1997. Surficial Geology of the Markham Area, NTS 30M/14, southern Ontario. Geological Survey of Canada, Open File 3300. Scale 1:50 000.



MAP NOTES

The surficial geology of the Markham area has been mapped in part by several workers: Wait, 1967; Hewitt, 1969; Karrow, 1970; Barnett, 1992; Sharpe, 1997; Sharpe, 1998. These maps and the original field data (~1900 sites), combined with new map data (1992-1996; ~600 sites; Fig. 3), and a new regional evaluation are synthesized in the present map. Highlights of the map include a marked reduction in the previously recognized extent and thickness of the Hainan drift and a corresponding greater surface extent to the Newmarket Till. Newmarket Till contains a complex of strata that can be traced to the north and found to underlie the ORM (Barnett, et al., 1991; Sharpe et al., 1994). It is reported to have a NS-SW fabric (e.g. Gwyn, 1978) indicating ice flow from the northeast (Barnett, 1992; Boyce et al., 1995). Along Lake Ontario bluff, a NW-SE fabric, a north-south paleoflow in sand and silt containing older beds (Scarborough fm), indicates local flow from Lake Ontario. Northwest-southeast oriented flutings and drumlins are common on the Newmarket Till in the southeast corner of the area. These forms and the other drumlins are erosional and formed by subglacial meltwater or glacial erosion. Hainan Till is concentrated on or near the south flank of the ORM where it is a silt till (clayey silt in lows and west in the Botton-Donner area; Karrow, 1959). It has common silt, fine sand, debris-flow interbeds and a low (1-2%) stone content. Hainan Till has a sandy silt texture where it overlies sand. The south-southwest orientation shows the regional aspect of Newmarket Till and the restricted distribution of the Hainan Till, particularly south of the Markham basin. The distribution and character of the Hainan Till in the Markham area, indicates that it was deposited by ice melting back from the Oak Ridges Moraine. Thick diamicton (deltaic loess?) accumulated closer to the moraine in a zone where an advance of a few km may have occurred. Thin till and interbedded fine sand, silt and clay accumulated further north. Little Hainan drift was deposited about 40 m to the south, except in bedrock valleys where drift is much thicker. This drift or was stagnated to effectively halt sediment supply in the southern half of the area. The SE-WN orientation of drumlins was considered to indicate formation of the underlying (Hainan) lacustrine plain, a major valley of the Hainan and the Iroquois Lake buff. ORM consists of hummocky and kettled terrain, and gullies cut by post-depositional erosion or landsliding on lacustrine silt. The Markham till-lake plain is marked by NW-SE oriented ridges (drumlins) and a low sediment scarp facing northwest (Fig. 6). The latter forms a shallow basin covered by thin, widespread silt and fine sand. To the south, Newmarket Till forms an extensive terrain that is related to the Peterborough drumlin drift to the north of the area. Duffins Creek valley dissects the Newmarket Till drainage east of Clarendon. A network of valleys north of the ORM have been interpreted as channels cut by powerful subglacial meltwater flows (e.g. Baer, 1970). Enhanced postglacial gullying is also found along tributaries of Duffins Creek east of Clarendon.

Physiography and Landforms:

The area consists of four prominent terranes (Fig. 1): Oak Ridges Moraine, a southern (Markham) illi-lacustrine plain, a major valley of the Hainan and the Iroquois Lake buff. ORM consists of hummocky and kettled terrain, and gullies cut by post-depositional erosion or landsliding on lacustrine silt. The Markham till-lake plain is marked by NW-SE oriented ridges (drumlins) and a low sediment scarp facing northwest (Fig. 6). The latter forms a shallow basin covered by thin, widespread silt and fine sand. To the south, Newmarket Till forms an extensive terrain that is related to the Peterborough drumlin drift to the north of the area. Duffins Creek valley dissects the Newmarket Till drainage east of Clarendon. A network of valleys north of the ORM have been interpreted as channels cut by powerful subglacial meltwater flows (e.g. Baer, 1970). Enhanced postglacial gullying is also found along tributaries of Duffins Creek east of Clarendon.

Quaternary Geology: Older Deposits:

(Karrow, 1967); beneath regional sediments deposited during the late Wisconsinan (25-12ka). Such beds are the organic-rich sandy Scarborough Formation, can be traced from the Scarborough Bluffs to the GSC borehole 05.1 north of Preston Lake. Silty Thorncliffe Formation can be traced to south of Whitwell and east of Willowdale.

Till:

Newmarket Till, a dense, pebbly, sandy silt diamicton, is the most common unit on the map, appearing in a broad SW-NE belt forming a slight upland (Fig. 5) running from south of Clarendon to southwest of Markham. Sandy till found on the south slope of the Oak Ridges Moraine is mapped as a sandy facies of Hainan Till where it underlies this sediment. In other areas,

Recent Deposits:

Some ORM sediments have a gullied character that is secondary to a typical kettled, hummocky appearance. Northwest-oriented gullies appear related to the drop in lake (Pleistocene) level following the glaciolacustrine phases of moraine formation. Fine sand has been eroded along the West Don River and elsewhere along Mitchell Creek, where it underlies a thin cap of Hainan Till. This terrace has a distinct glacial character. Fluvial erosion cut deep valleys in the Don, Gougeon and Duffins Creek (alluvial) water courses.

STRATIGRAPHY

Explanation of stratigraphic terms in the ORM NATMAP area

Stratigraphic unit	Map units	Explanation / description / reference to stratigraphic names
Quaternary		
Recent		
11	11	Recent covering 2 million years of glacial climates. Last 10,000 years following glacial climatic. Deposits along shore of modern lake.
10	10	Deposits deposited by modern rivers in flood plain. Plant and animal matter accumulated in wetlands. Sediment deposited by rivers in terraces and eskers during glacial time.
9	9	Time of advance and retreat of large ice sheets (2 million to 10,000 years ago). The till of the largest glacial lakes in Lake Ontario / Lake Huron basins. Series of lake levels deposited against the ORM as the glacier blocked drainage (approximately 18000 ad).
8	8	Deposits of high-energy alluvial or current-bank from a glacier; may form core of DEM.
7	7	Interbedded with lake deposits and beneath the Collin O'Brien. (1973; Barnett et al., 1991).
6	6	Thin, heavily gullied lake deposits, meeting or nested beneath 7a or lower beds (Chapman and Putnam, 1942; Barnett, 1995).
5	5	May grade upward into Hainan Till (Karrow, 1959; Lawless, Karrow, 1967).
4	4	Port Stanley / Lake Ontario contact till; Hainan Lake shore contact till (Barnett, 1991).
Unconformity		
		Major erosional / glacial contact with former terrace and channel cutting and escurring channels produced by subglacial drainage (cf. Barnett, 1995).
		Newmarket / Upper Ledaia / Boremanville till
		Upper Thorncliffe Formation / Clarke beds
		Lower Thorncliffe Formation / Clarke beds
		Scarborough Formation
		Hainan Till (Boremanville)
		Collin O'Brien (C.O.) till (see unit 7) and clayey / silty / sand (see unit 6)
		Warmwater ($<10^{\circ}$ C) till (see unit 6)
		Dane, sandy till from glacial period prior to last major warm period (Karrow, 1957)
		Undifferentiated stratified sediment, dominantly sand, some pebbles
		Clear silt and clay
		Long interval with no deposits and/or major erosion
		Perched covering: 250 - 570 million years ago (Libbey, 1995)
		Ancient marine rocks
		Mass uplift with 1100 m of uplift of glacial deposits on bedrock
		Rocks below from grains of sediment (completely east of w. Georgian Bay/Niagara Escarpment)
		Limestone and dolostone rocks, found respectively east and west of the Queen's Quay
Paleozoic		
		Bedrock
		Bedrock complex
		Clastic (sandstone or shale)
		Carbonate

SERIES BIBLIOGRAPHY

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 Boyce, J., 1995. Surficial geology of the Markham Area, NTS 30M/14, southern Ontario. Geological Survey of Canada, Open File 3300.
 ... (many other references omitted for brevity) ...

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 M. G. Bennett for providing the digital elevation model (DEM) data.
 ... (many other names omitted for brevity) ...

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